



## ***Radiation Protection Competency 2.1***

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**Competency 2.1** Radiation protection personnel shall demonstrate a working level knowledge of the following Federal regulations, codes, notices and DOE Orders related to radiation protection.

- **10 CFR 835, *Occupational Radiation Protection***
- **DOE N 5400.13, *Sealed Radioactive Source Accountability***
- **DOE Order 5400.5, *Radiation Protection of the Public and the Environment***
- **DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards***
- **DOE Order 5480.11, *Radiation Protection for Occupational Workers***
- **Office of Health Implementation Guides for use with Title 10 CFR Part 835**

### **1. Supporting Knowledge and/or Skills**

- a. Describe the relevant requirements, interrelationships, and importance of the listed Orders, notices, codes, and regulations.
- b. Describe the methods by which Order and/or regulatory compliance is determined and communicated to Department and contractor management.
- c. Discuss the role of radiation protection personnel with respect to these Orders and regulations.

### **2. Summary**

The relevant requirements, interrelationships, and importance of the DOE Orders, notices, codes, and regulations listed above are summarized on the next page. Radiation protection personnel have a responsibility to utilize and implement applicable regulations issued by DOE.



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<b>10 CFR 835, Occupational Radiation Protection</b>	
<b>Purpose</b>	Implements, within DOE, the Radiation Protection Guidance to Federal Agencies for Occupational Exposure and other radiation protection standards. The standards set forth in this rule help to ensure that DOE facilities are operated in a manner such that occupational radiation exposure to workers is maintained within acceptable limits and as low as reasonably achievable (ALARA).
<b>Scope</b>	DOE facilities
<b>Requirements/ Key Words</b>	<p><u>Subpart A, General Provisions</u>, establishes radiological protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from DOE activities.</p> <p><u>Subpart B, Radiation Protection Programs (RPP)</u>, includes the plans, schedules, and measures to be taken by the M &amp; O Contractor to comply with all requirements in 10 CFR 835. An RPP for each DOE site was due on Jan. 1, 1995 to DOE Headquarters.</p> <p><u>Subpart C, Standards for Internal and External Exposure</u>, addresses limits for:</p> <ul style="list-style-type: none"> <li>• General employees (occupationally exposed)</li> <li>• Minors (occupationally exposed)</li> <li>• General public</li> </ul> <p>It also addresses:</p> <ul style="list-style-type: none"> <li>• Planned special exposures</li> <li>• Nonuniform exposure of the skin</li> <li>• Concentrations of radioactive material in the air</li> </ul> <p><u>Subpart D, Reserved</u></p> <p><u>Subpart E, Monitoring in the Workplace</u>, addresses:</p> <ul style="list-style-type: none"> <li>• General requirements</li> <li>• Instrumentation</li> <li>• Individual monitoring - external</li> <li>• Individual monitoring - internal</li> <li>• Area monitoring</li> <li>• Radioactive contamination control and monitoring</li> </ul> <p><u>Subpart F, Entry Control Programs</u>, addresses:</p> <ul style="list-style-type: none"> <li>• Radiological Areas</li> <li>• High Radiation Areas</li> <li>• Very High Radiation Areas</li> </ul>



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10 CFR 835, <i>Occupational Radiation Protection</i> (cont.)	
<b>Requirements/ Key Words (cont.)</b>	<p><u>Subpart G, Posting and Labeling</u>, addresses requirements for signs:</p> <ul style="list-style-type: none"> <li>• DOE-approved signs</li> <li>• Yellow background</li> <li>• Black or magenta radiation symbols</li> <li>• Clear and conspicuous signs and specific posting requirements for:               <ul style="list-style-type: none"> <li>- Controlled Areas</li> <li>- Radiation Areas</li> <li>- High Radiation Areas</li> <li>- Very High Radiation Areas</li> <li>- Airborne Radioactive Areas</li> <li>- Contamination Areas</li> <li>- High Contamination Areas</li> </ul> </li> </ul> <p><u>Subpart H, Records</u>, addresses requirements for documenting compliance with Part 835, the RPP, and, in particular, those actions that demonstrate compliance with the ALARA provisions of the rule.</p> <p><u>Subpart I, Reports to Individuals</u>, requires, on an annual basis, each DOE-facility or DOE contractor-operated facility to provide each individual monitored for occupational exposure a radiation dose report of his/her occupational exposure at the facility.</p> <p><u>Subpart J, Radiation Safety Training</u>, requires the training of general employees, radiological workers, and control technicians; verification by examination; intervals of training not to exceed two years; and a provision for acceptance of training from other facilities.</p> <p><u>Subpart K, Design and Control</u>, addresses added emphasis on facility and equipment design and administrative controls in order to maintain radiological exposures ALARA.</p> <p><u>Subpart L, Release of Materials and Equipment from Radiological Areas</u>, cannot be removed from controlled areas unless measurements are made to establish that removable contamination, and the combination does not exceed predetermined values.</p> <p><u>Subpart M, Reserved</u></p> <p><u>Subpart N, Accidents and Emergencies</u>, addresses:</p> <ul style="list-style-type: none"> <li>• Employees who have exceeded dose limits</li> <li>• Emergency exposure guidelines</li> <li>• Nuclear accident dosimetry</li> </ul>

10 CFR 835, *Occupational Radiation Protection*, codifies existing DOE radiation protection directives as they apply to occupationally exposed workers at DOE facilities. Codification of the existing directives provides the basis for assessment of civil and criminal penalties (under the Price-Anderson Amendments Act) for violations of nuclear safety requirements found in the final rule. One of the most important impacts of 10 CFR 835, therefore, is that the enforcement power of the Department is greatly enhanced.



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The requirements in 10 CFR 835 are mandatory. Compliance with published guides in support of 10 CFR 835, such as the *Implementation Guides*, or guidance documents such as the DOE *Radiological Control Manual*, is not required unless committed to by the facility in their contractual agreement. One of the most important requirements in 10 CFR 835 is that facilities have a documented radiation protection program (RPP) approved by DOE. The RPP is used by DOE auditors to assess compliance. The other major areas included in 10 CFR 835 are:

- Definitions
- Standards for Internal and External Exposure
- Monitoring in the Workplace
- Entry Control Program
- Posting and Labeling
- Records
- Reports to Individuals
- Radiation Safety Training
- Design and Control
- Releases of Material and Equipment from Radiological Areas

There are some areas related to radiation protection of workers that are not included in 10 CFR 835. These areas are packaging and transportation of radioactive material, respiratory protection, and transfer or discharge of radioactive waste. Requirements for these areas are found in other DOE Orders. Other areas not specifically included in 10 CFR 835 are sealed source accountability and tritium surface contamination.

To assist individuals responsible for carrying out the requirements of 10 CFR Part 835, DOE has issued (December 1993) and subsequently revised (November 1994), a series of Implementation Guidance (IGs) documents covering a variety of topics found in the final rule. These guides include the following areas:

- Radiation Protection Program
- Occupational ALARA Program
- Internal Dosimetry Program
- External Dosimetry Program
- Radiation-Generating Devices
- Evaluation and Control of Fetal Exposure
- Instrument Calibration for Portable Survey Instruments
- Workplace Air Monitoring
- Posting and Labeling for Radiological Control
- Occupational Radiation Protection Recordkeeping and Reporting
- Radiation Safety Training
- Sealed Radioactive Source Accountability and Control



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In addition to guidance designed to implement the final rule, position papers have also been issued by DOE to clarify technical issues that have surfaced regarding the implementation of 10 CFR 835.

<b>DOE N 441.1, Radiological Protection for DOE Activities</b>	
<p><b>NOTE:</b> DOE N 441.1 supersedes DOE N 5400.13, <i>Sealed Radioactive Source Accountability</i>, and DOE Order 5480.11, <i>Radiation Protection for Occupational Workers</i>.</p> <p>Contractors shall be directed to continue to comply with the requirements of orders canceled by this notice until their contracts are modified to delete the reference to the requirements of the canceled orders.</p>	
<b>Purpose</b>	Establishes radiological protection program requirements that, combined with 10 CFR 835 and its associated implementation guidance, form the basis for a comprehensive program for protection of individuals from the hazards of ionizing radiation in controlled areas. These requirements shall remain in effect pending completion of the department's rulemaking efforts to codify these or equivalent requirements.
<b>Scope</b>	This Notice applies to all defense nuclear facilities classified as hazard categories 1, 2, or 3 that are subject to the requirements of 10 CFR 835, and to contractors that operate defense nuclear facilities.
<b>Requirements/ Key Words</b>	<p><u>Administrative Control Levels</u> A system of administrative control levels (ACLs) shall be implemented to control radiological worker doses at levels below the occupational exposure limits provided in 10 CFR 835.202.</p> <ol style="list-style-type: none"> <li>1. A DOE ACL of 2 rem (0.02 Sv) total effective dose equivalent (TEDE) per year shall be implemented. No individual shall be permitted to receive an occupational exposure during planned activities that would result in exceeding the DOE ACL without the specific written authorization of the cognizant secretarial officer or designee.</li> <li>2. A cumulative total effective dose equivalent (CTEDE) ACL of 1 rem (0.01 Sv) TEDE per year of age shall be implemented. When a radiological worker's CTEDE exceeds 1 rem TEDE per year of age, special ACLs shall be established during ensuing years as necessary to cause that individual's CTEDE to approach and, if possible, fall below 1 rem per year of age.</li> <li>3. A facility-specific ACL shall be approved each year by facility management to maintain radiological worker doses below the DOE ACL. Written authorization by facility management shall be required prior to allowing any radiological worker's dose resulting from planned activities to exceed the facility-specific ACL.</li> </ol> <p><u>Work Authorizations</u> Authorizations to work in radiological areas shall be in accordance with the RPP required by 10 CFR 835.101. This program, in part, shall describe a radiological work authorization program as specified in 835.501 that appropriately utilizes available work documents and procedures. The level of detail included in these documents shall be commensurate with the nature and magnitude of the hazard and complexity of the required controls.</p>



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<b>DOE N 441.1, Radiological Protection for DOE Activities (cont.)</b>	
<b>Requirements/ Key Words (cont.)</b>	<p><u>Radiation Safety Training</u></p> <ol style="list-style-type: none"> <li>1. Radiation safety training for general employees, radiological workers, and radiological control technicians shall utilize those portions of the standardized core training materials published by DOE that are relevant to facility hazards and operations, augmented as necessary by site-specific materials. Documentation of satisfactory completion of the entire DOE standardized core course(s) shall be accepted by all DOE activities.</li> <li>2. Training requirements commensurate with the hazard within a posted area shall be completed by an individual prior to permitting unescorted access to that area.</li> </ol> <p><u>Posting</u></p> <p>Any accessible area in which radioactive material is used, handled, or stored shall be posted with the words "Caution, Radioactive Material." The posting shall meet the requirements of 10 CFR 835.601. The following areas are exempt from this posting requirement:</p> <ol style="list-style-type: none"> <li>1. Areas containing 10 or fewer sealed radioactive sources with activities below the accountability criteria established in Attachment 1, Values for Exemption of Sealed Radioactive Sources from Inventory and Source Integrity Tests.</li> <li>2. Areas containing only materials that are properly packaged and labeled for transport in conformance with Department of Transportation (DOT) regulations or corresponding DOE directives, and that are expected to enter into transportation in the immediate future (i.e., the current shift).</li> <li>3. Areas under continuous observation and control of an individual knowledgeable of and empowered to implement required access control measures.</li> <li>4. Areas posted as radiological areas in accordance with 10 CFR 835.603.</li> <li>5. Other areas posted with radiological warning signs meeting the criteria established in 10 CFR 835.601.</li> <li>6. Areas containing radioactive materials in quantities below the site- or facility-specified posting threshold. This threshold shall be established at a level below that which is likely to cause any individual to receive a TEDE in excess of 0.1 rem in a year.</li> </ol> <p><u>Control of Sealed Radioactive Sources</u></p> <ol style="list-style-type: none"> <li>1. Administrative procedures shall be developed and maintained to control sealed radioactive sources having values equal to or exceeding those in Attachment 1, Values for Exemption of Sealed Radioactive Sources from Inventory and Source Integrity Tests.</li> <li>2. Accountable sealed radioactive sources, or their storage containers or devices, shall be labeled with the standard radiation warning trefoil and the words, "Caution, Radioactive Material."</li> </ol>



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DOE N 441.1, <i>Radiological Protection for DOE Activities</i> (cont.)	
<b>Requirements/ Key Words (cont.)</b>	<p><u>Control of Sealed Radioactive Sources</u> (cont.)</p> <ol style="list-style-type: none"> <li>3. An individual shall be designated to maintain control of assigned accountable sealed radioactive sources. Prior to being designated, the individual selected shall be trained as a radiological worker in accordance with 10 CFR 835.902 and instructed on site-specific source control procedures.</li> <li>4. Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. A two-month grace period may be used to accommodate scheduling needs. This inventory shall establish:             <ul style="list-style-type: none"> <li>• The physical location of each accountable sealed radioactive source.</li> <li>• The adequacy of associated postings and labels.</li> <li>• The adequacy of storage locations, containers, and devices.</li> </ul> </li> <li>5. Each accountable sealed radioactive source having an activity exceeding 0.005 <math>\mu\text{Ci}</math> shall be subject to a source integrity test upon receipt, when damage is suspected, and at intervals not to exceed six months. A six-week grace period may be used to accommodate scheduling needs. Source integrity tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 <math>\mu\text{Ci}</math>.</li> <li>6. Notwithstanding the requirements of paragraph 6.e.(5), an accountable sealed radioactive source is not subject to a periodic source integrity test if that source has been documented to have been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory as required by paragraph 6.e.(4) of this section, and subject to a source integrity test prior to being returned to service.</li> <li>7. Notwithstanding the requirements of paragraph 6.e.(4) and 6.e.(5), an accountable sealed radioactive source is not subject to periodic inventory and source integrity tests if that source is located in an area that is inaccessible to individuals due to operational or environmental constraints.</li> <li>8. An accountable sealed radioactive source found to be leaking radioactive material at a level exceeding 0.005 <math>\mu\text{Ci}</math> shall be controlled in a manner that prevents the escape of radioactive material to the workplace.</li> </ol> <p><u>Exposure of Minors</u></p> <p>The exposure of minors during direct onsite access to a DOE site or facility shall be controlled such that the dose to the extremities, lens of the eye, and other organs and tissues does not exceed 10% of the corresponding occupational exposure limits established in 10 CFR 835.202. Appropriate monitoring of external and internal dose shall be performed to demonstrate compliance with these limits.</p> <p><u>DOE Laboratory Accreditation Program (DOELAP)</u></p> <p>DOELAP shall be maintained consistent with the applicable DOE standards, and dosimetry programs shall be accredited at periodic intervals consistent with the standards. Additional guidance for the various program elements are contained in the DOELAP Technical Standard.</p>

DOE Order 5480.11, *Radiation Protection for Occupational Workers*, preceded 10 CFR 835. It is



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one of several DOE Orders that has been canceled and replaced by DOE Notice 441.1, *Radiological Protection for DOE Activities*. Notice 441.1 consists of a series of performance based requirements designed to supplement and augment the requirements of 10 CFR 835. In DOE's view, the combination of N 441.1, 10 CFR 835, and available implementation guidance forms the basis for an acceptable radiological protection program.

**NOTE:** Cancellation of an Order does not relieve the contractor from meeting terms and conditions of their contractual agreement. Contractors meeting the requirements of DOE Order 5480.11 until contract renewal are treated as being in compliance with 10 CFR 835.

DOE Notice 5400.13, *Sealed Radioactive Source Accountability*, also has been superseded by Notice 441.1. In the area of sealed source control, N 441.1 addresses the issues of developing and maintaining administrative procedures, taking inventories at specified intervals, labeling sources in an appropriate manner, and performing source integrity (leak) testing at certain frequencies. This notice also includes a table of values for exempting sealed sources from inventory and source integrity tests.

<b>DOE Order 5400.5, <i>Radiation Protection of the Public and the Environment</i></b>	
<b>NOTE:</b> DOE Order 5400.5 is due to be superseded by 10 CFR 834, <i>Radiation Protection of the Public and the Environment</i> .	
<b>Purpose</b>	Protects the public and the environment against undue risk of radiation due to operations of DOE and DOE contractor facilities.
<b>Scope</b>	DOE and DOE contractor facilities
<b>Requirements/ Key Words</b>	<p><u>Chapter I, General Summary</u> DOE is primarily adopting the Internal Commission on Radiological Protection (ICRP) 26/30 system of dose calculation, limitation, etc. The DOE primary standard is 100 mrem effective dose equivalent (EDE) in a year above background to members of the public from all pathways and sources. (This is reduced from the previous primary standard of 500 mrem in a year, since it is already largely being achieved and it follows the ICRP recommendation).</p> <p><u>Chapter II, Requirements for Radiation Protection of the Public and the Environment</u> The primary limit of 100 mrem EDE in a year is described in detail. The limit includes all pathways and sources and internal and external exposure. It does not include doses received from occupational exposures, naturally occurring background radiation, medical radiation, consumer products, or fallout. If justified, the public dose limit can be temporarily increased to 500 mrem through a request to EH-1.</p>





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<b>DOE Order 5400.5, <i>Radiation Protection of the Public and the Environment</i> (cont.)</b>	
<b>Requirements/ Key Words (cont.)</b>	<p><u>Chapter III, Derived Concentration Guides (DCGs) for Air and Water</u> DCGs are concentrations of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (e.g., ingestion of water), would result in an effective dose equivalent of 100 mrem. These are not limits, but tools to be used in meeting the basic requirements.</p> <p><u>Chapter IV, Residual Radioactive Material</u> Residual Radioactive Material:</p> <ul style="list-style-type: none"><li>• Originally issued as guidance for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP)</li><li>• Chapter IV of DOE Order 5400.5 now applies DOE-wide.</li><li>• Basic dose limit is 100 mrem above background EDE in a year due to residual radioactive material. It is expected that the potential doses associated with actual or likely use of the released property will be a few mrem or less. This limit applies to all sources and pathways (excluding background and medical). The limits for radon and radon progeny are addressed separately.</li><li>• Guidelines for residual radioactive material in soil shall be derived by environmental pathway analysis except for thorium (Th) and radium (Ra). The RESRAD computer program is recommended, but alternate procedures are acceptable.</li></ul>

**NOTE:** DOE Order 5400.5 is in the process of being codified under 10 CFR 834

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, establishes standards and requirements for operations of the DOE and its contractors with respect to protection of the public and the environment against undue risk from radiation. The Order is divided into four chapters that discuss the general topics covered in the Order, requirements for radiation protection of the public and the environment, DCGs for air and water, and residual radioactive material.

### Chapter I, General Summary

The first chapter serves as a general introduction. The chapter highlights ICRP recommended methodology, the DOE primary dose standard, the ALARA philosophy, treatment technologies, and compliance with the Order.

Specifically, DOE:

- Adopts the ICRP 26/30 methodology recommended in 1977. (**NOTE:** Since the issuance of DOE Order 5400.5, the ICRP has published new recommendations on radiation protection, ICRP 60.)
- Uses a primary dose standard of 100 mrem in a year. This is an EDE from all sources and all pathways.



- Adopts the As Low As Reasonably Achievable (ALARA) philosophy. This means that in this Order, ALARA is no longer a recommended practice, but rather a required part of the radiation protection program.
- Adopts the Best Available Technology (BAT) as the appropriate level of treatment for liquid wastes at the point of discharge.
- Calls for the phasing out of soil columns to prevent the buildup of contamination in soils and groundwater, thereby protecting the environment.
- Requires compliance with the Order through effluent monitoring, environmental surveillance, computer modeling, and dose conversion factors.

### Chapter II, Requirements for Radiation Protection of the Public and the Environment

The primary dose limit for members of the public is 100 mrem EDE in a year from all sources and all pathways. The EDE was originally defined by the ICRP when they introduced a risk-based system in ICRP 26. The EDE allows the summation of external and internal doses. The primary dose limit, therefore, includes exposures from sources external to the body during the year and the committed EDE from radionuclides taken into the body during the year. This limit does not apply, however, to doses from medical exposures and consumer products. The limit does not generally apply to naturally-occurring radioactivity and accident conditions. Authorization to exceed the primary standard is possible, but requires approval from DOE officials (EH-1).

Other limits specified in this chapter are:

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| • Airborne emissions (40 CFR 61)                                     | 10 mrem (0.1 mSv) EDE  |
| • Spent nuclear fuel, high-level and transuranic wastes (40 CFR 191) | 25 mrem (0.25 mSv) whole body<br>75 mrem (0.75 mSv) any organ  |
| • For drinking water (40 CFR 141)                                    | 4 mrem (0.04 mSv) EDE at the tap<br>5E-9 $\mu$ Ci/ml (Ra-226 + Ra-228)<br>1.5E-8 $\mu$ Ci/ml gross alpha |

The regulation of airborne emissions is required under the Clean Air Act, which, in turn, precipitated the issuance of 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants*. The airborne limit of 10 mrem is based on releases to the atmosphere from routine DOE activities. Exposures from radon-220 (Rn-220), radon-222 (Rn-222), and their progeny are subject to separate DOE limits.

Note that the limits for spent nuclear fuel facilities, etc., are not in EDE units since both whole body and organ doses are specified. Simply stated, 40 CFR 191, *Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes*, was written several years ago using ICRP 2 methodology, which treated external and internal doses separately.



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The drinking water limits in this order are based on 40 CFR 141, *National Interim Primary Drinking Water Regulations* (Safe Drinking Water Act), a regulation that was also written prior to the advent of the EDE. However, it is listed here as an EDE because DOE has chosen to do so. The 4 rem limit applies to community water systems that serve at least 15 connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

As stated earlier, the ALARA approach is now required for DOE activities and facilities that could result in public doses. DOE Order 5400.5 lists several factors that should be considered in an ALARA program. Quantitative cost-benefit analyses of many of these of these factors can be both expensive and difficult to evaluate. Therefore, flexibility is given in the Order to perform qualitative ALARA analyses in those instances where doses are well below the limits and requirements of the National Environmental Policy Act (NEPA) have been met. Analyses of a quantitative nature are definitely required, however, when potential doses approach the limit.

To assist DOE personnel and their contractors in the implementation of the ALARA process as it relates to DOE 5400.5, DOE issued *DOE Guidance on the Procedures in Applying the ALARA Process for Compliance With DOE 5400.5*, DOE now requires tightened controls on the discharge of liquid effluents from its facilities. The objective is to protect resources such as land, surface water, and groundwater from undue contamination. This has created the need for an evaluation of BAT. According to the Order, a BAT review is required for liquid wastes containing radionuclides discharged to surface waters if these waters would contain, at the point of discharge and prior to dilution, radioactive material at an annual average concentration greater than the DCGs (listed in Chapter III) for liquids. A DCG, by definition, is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode, would result in an EDE of 100 mrem (1 mSv). For multiple releases, the sum of fractions method is used where the concentration of each radionuclide is divided by its respective DCG, summed for each radionuclide, and compared to one (meaning the sum of fractions cannot exceed 1).

Several factors affect the BAT review, including the age of the facility; cost; and environmental, safety, and public impacts. At the present time, there is an exemption for tritium, since no BAT is available. DOE issued an interim final report, DOE/EH-263T, *Implementation Manual for Application of Best-Available Technology Processes for Radionuclides in Liquid Effluents*, in June 1992 to provide guidance and explanation of the requirements for BAT effluent control found in DOE 5400.5.

To prevent the buildup of radioactivity in sediment, limits exist for the levels of alpha and beta-gamma settleable solids found in a liquid process waste stream released to natural waterways.

For gross alpha: <5 pCi/g above background

For gross beta: <50 pCi/g above background



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To protect native animal aquatic organisms, the absorbed dose from exposure to radioactive material in liquid wastes discharged to natural waterways must not exceed 1 rad per day. This limit is based on information contained in NCRP Report #109, *Effects of Ionizing Radiation on Aquatic Organisms*.

The use of soil columns (trenches, cribs, ponds, drain fields, etc.) for retaining, by sorption or ion exchange, suspended or dissolved radionuclides from liquid waste streams, must be phased out and replaced by an acceptable alternative. Each facility is responsible for developing a plan and schedule for alternate disposal methods.

The BAT review process is implemented in some instances not just for liquid discharges to surface waters (as noted above), but also for releases to sanitary sewers where radionuclide concentrations, averaged monthly, would otherwise be greater than 5 times the DCG values for liquids (given in Chapter III) at the point of discharge.

In the codification of DOE 5400.5 to 10 CFR 834, total curie limits may apply. These limits (as stated in the draft version of 10 CFR 834) are:

- 5 Ci hydrogen-3
- 1 Ci carbon-14
- 1 Ci all other radionuclides

Compliance with the dose limits in the Order are demonstrated through documentation and recordkeeping, effluent monitoring, environmental surveillance, dose conversion factors, EPA approved computer models, comparison with DCG values, and other methods with the approval of the Assistant Secretary for Environment, Safety and Health (EH-1).

### **Chapter III. Derived Concentration Guides for Air and Water**

The DCG values listed in this chapter are provided as guideline reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. DAC values for occupational intake of radionuclides through inhalation can be found in the appendices to 10 CFR 835).

DCG values are included for each of three exposure modes: ingestion of water, inhalation of air, and immersion in a gaseous cloud. Other potentially significant exposure pathways are not included in this chapter; therefore, specific pathway analyses would have to be performed for calculating public radiation doses.

Since the DCG values for internal exposure are based on a CEDE of 100 mrem, comparison with the DOE drinking water criterion of 4 mrem is accomplished by taking 4% of the DCG values for ingestion.



### **Chapter IV, Residual Radioactive Material**

This chapter provides radiological protection requirements and guidance for the cleanup of residual radioactive material and the management of the resulting wastes, residues, and release of property. The criteria for cleanup of residual radioactive material used in this chapter originally applied to sites under the FUSRAP and the SFMP. These criteria now apply DOE-wide.

Residual radioactive material, as used in this chapter, includes residual concentrations of radionuclides in soil, airborne concentrations of radon progeny, external gamma radiation levels, surface contamination limits, and radionuclide concentrations in air or water resulting from or associated with any of the above.

The basic dose limit for the public from exposures to residual radioactive materials above natural background levels is 100 mrem (1 mSv) EDE. This limit applies to all sources and all release pathways from the facility or site in question. Separate limits apply to radon and its progeny.

For soil, residual concentrations of radioactive material are defined as those concentrations exceeding background concentrations when averaged over 100 square meters. Generic guidelines, i.e., guidelines independent of the property and that therefore apply to all facilities, are taken from existing radiation protection standards. For the radionuclides radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), and thorium-232 (Th-232), these generic values are:

- 5 pCi/g averaged over the first 15 cm of soil below the surface
- 15 pCi/g averaged over succeeding 15 cm layers of soil more than 15 cm below the surface.

Site-specific release limits require a pathway analysis utilizing specific property data and the computer program *RESRAD*, which was developed by the Argonne National Laboratory. Hot-spot criteria also exist.

Limits for airborne radon decay products are taken from 40 CFR 192. The objective of the remedial action is to achieve an annual average (or its equivalent) of 0.02 WL, including background. In no case shall the radon progeny concentration exceed 0.03 WL (including background).

The limit for external gamma radiation (taken as an average level above background) is 20  $\mu$ R/h inside a building or habitable structure on a site to be released without restrictions. This value similarly comes from 40 CFR 192.



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Surface contamination guideline values, expressed in typical units of dpm/100 cm<sup>2</sup>, are detailed in the table that follows. These guidelines were adapted by DOE from U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors* (1974), and the NRC publication, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material* (1982). The guideline values are applicable to existing structures and equipment.

### Surface Contamination Guidelines

Allowable Total Residual Surface Contamination (dpm/100 cm <sup>2</sup> )			
Radionuclides	Average	Maximum	Removable
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	RESERVED	RESERVED	RESERVED
Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay product; alpha emitters	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

The Order establishes authorized limits for residual radioactive material that should be set equal to the generic or DCGs, unless it can be shown that the DCGs are not appropriate for use at the specific property.



## ***Radiation Protection Competency 2.1***

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Residual radioactive material must also be managed. DOE Order 5400.5 discusses several ways this can be achieved:

- Interim storage - Control and stabilization features shall be designed to provide for a minimum life of 25 years and an effective life of 50 years. Provisions for the control of Rn-222 and groundwater concentrations, quantities of residual radioactive material, site access, and use of onsite material must be established.
- Interim management - Generally applies when the residual radioactive material is in inaccessible locations and would involve a significant financial burden to remove.
- Long-term management - For uranium, thorium, and their decay products, control and stabilization features shall be designed to provide for a minimum life of 200 years and an effective life of 1,000 years. Control of Rn-222 emanation rates, groundwater concentrations, residual radioactive material, site access, and the use of onsite material must be established. The long-term management of other radionuclides is conducted under the provisions of DOE 5820.2A, *Radioactive Waste Management*.

Supplemental limits and exceptions can be requested in certain circumstances where the guidelines or authorized limits established for the site in question are not appropriate. Supplemental limits can allow uncontrolled release of the site without radiation restrictions; however, the basic dose limit of 100 mrem must still be achieved. Exceptions require that some restrictions be placed on the site (no farm use, for example). Any exceptions must be justified and ensure that the basic public dose limits are met. Control of residual radioactive material must still be established.

DOE Order 5480.4, *Environmental Protection, Safety and Health Protection Standards*, has a three-fold purpose: (1) specify and provide requirements for applying mandatory environmental protection, safety, and health standards applicable to DOE and DOE contractor organizations; (2) list standards from many agencies and organizations; and (3) identify sources of mandatory and reference environmental safety and health standards.

### **3. Self-Study Scenarios/Activities and Solutions**

#### **Review**

- 10 CFR 835, *Occupational Radiation Protection*
- DOE N 441.1, *Radiological Protection for DOE Activities*
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
- DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*
- DOE *Implementation Guides* for use with 10 CFR 835

#### ***Scenario***







## *Radiation Protection Competency 2.1*

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Several potential radiation hazards exist in this scenario. Essentially, the contractor has lost control over a large source. While it does not appear that overexposures occurred, they very easily could have if circumstances had been only slightly different. For example, the calibrator could have been dismantled to the point that the source was exposed, or the dismantling process could have ruptured the source, adding potentially significant contamination concerns to the scenario. Furthermore, since workers in the lab were apparently unaware of the presence of the calibrator, it could have easily been cleared out as unwanted equipment and possibly lost. Even if the researcher had stayed, modifications to such a piece of equipment should be carefully planned and scrutinized for a potential breach of original safety features. It appears that this process was not being strictly controlled; otherwise, consequences to the project of the researcher leaving would have been apparent to other personnel. Also, the researcher should not have been allowed to leave with the calibrator unaccounted for and in a partially dismantled state.

Sections from the following DOE documents are pertinent to the above scenario:

### 10 CFR 835

- 835.2(a): The laboratory is a controlled area.
- 835.3(b): Contractor management is responsible.
- 835.101(b): DOE may direct modifications to an RPP.
- 835.202: Were dose limits exceeded?
- 835.704(b): ALARA actions must be documented.
- 835.1001: Design features.

### Notice 441.1

- 6e: Control of sealed radioactive sources.

### Order 5480.11

This Order would only be applicable if the contractor's contract had not been renewed since the effective date of 10 CFR 835.

### Implementation Guides

These would be applicable to the extent that the contractor committed to items contained in the RPP document and/or in the facility's contract with DOE. Regardless of the regulatory requirements, the implementation guidance documents issued by DOE contain valuable information that should have been reviewed and utilized by the researcher and other relevant personnel.

### DOE Order 5400.5

This Order is not directly applicable because the source was not taken offsite. No releases to the public or the environment apparently took place.



The following changes are appropriate:

- Per 10 CFR 835.1001, require strict control of equipment modifications for research purposes. Modifications should be planned (including potential new safety features) and approved. Maintenance personnel must be fully cognizant of not only existing safety features, the modification plan, and how it will affect the safety features, but also of the new safety features and their design. Part of the approval process should include periodic updates where problems can be identified and solved. If a change occurs, similar to the one in the scenario where the researcher left the facility, then radiation sources can be accounted for and safely secured.
- Require researchers who utilize radiation sources to account for all sources assigned to them before leaving the premises. The health physics staff should perform a visual inspection and survey of departing researchers' laboratories to account for all radiation sources. These requirements are appropriate items for the RPP.
- Recommend that the sealed radioactive source inventory of large sources (above a certain activity, for example) be performed at intervals shorter than six months. This could prevent the loss of large sealed sources.

#### **4. Suggested Additional Readings and/or Courses**

##### Courses

**NOTE:** See Appendix B for additional course information

- *Radiological Control Manual Training for Managers* -- Oak Ridge Institute for Science and Education.
- *Applied Health Physics* -- Oak Ridge Institute for Science and Education
- *Radiation Protection Functional Area Qualification Standard Training* -- GTS Duratek



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**NOTES:**

[illegible]